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Lynda Deschambault
Remedial Project Manager, Superfund Division
U.S. Environmental Protection Agency, Region 9
75 Hawthorne Street, 10th Floor (SFD 7-1)
San Francisco, California 94105

Subject: **Evaluation of Technical Results at Perimeter Drilling Locations LOC-39 and LOC-40**
Leviathan Mine Site
Alpine County, California

Dear Ms. Deschambault:

This letter transmits the technical results, preliminary interpretations, and conclusions and recommendations for wells installed during 2016 at perimeter drilling locations LOC-39 and LOC-40 east of Aspen Creek (Figure 1). This evaluation is submitted in partial fulfillment of the requirements of the Statement of Work attached to the *Administrative Order for Remedial Investigation and Feasibility Study, Comprehensive Environmental Response, Compensation, and Liability Act Docket No. 2008-18* issued by the U.S. Environmental Protection Agency (U.S. EPA) on June 23, 2008.

During the 2016 drilling program, un-nested deep monitoring wells MW-49 and MW-48 were installed at LOC-39 and LOC-40, respectively. The final *Drilling Work Plan, Leviathan Mine Site, Alpine County, California* (Drilling Work Plan) dated July 29, 2016, had called for installation of shallow wells at each location. The Drilling Work Plan stated that optional deeper wells would be installed later if water-level elevations in the shallow wells indicated that groundwater was moving offsite away from Aspen Creek toward the well locations east of Aspen Creek. For the reasons discussed below, the decision was made during implementation of the Drilling Work Plan to forego the shallow wells and proceed directly to installation of single deep wells at both locations. Groundwater elevations and groundwater sampling results collected from these wells in 2016 confirm that groundwater is not moving offsite to the east beneath or away from Aspen Creek. Therefore, and based on a thorough assessment of conditions encountered during well drilling, water-level measurements, and groundwater geochemistry, Atlantic Richfield's team concludes that additional nested shallow-depth monitoring wells at LOC-39 and LOC-40 are unnecessary for completing the Remedial Investigation and Feasibility Study (RI/FS). These attachments support this conclusion:

- Table 1 provides a detailed description of the original objectives at LOC-39 and LOC-40; results and observations recorded during drilling and from the subsequent monitoring of wells installed at these locations and interpretations, conclusions, and recommendations for each of the two locations.

- Tables 2 (Dissolved RI/FS Metals) and 3 (Field Parameters and General Chemistry) provide preliminary water-quality results for monitoring wells MW-48 and MW-49 from samples collected in September and October 2016.
- Figure 1 is an updated site-wide potentiometric surface map based on water-level data collected in November 2016. Figure 1 is based on water-level measurements from all new monitoring wells installed during 2016 including the monitoring wells along the eastern perimeter of the Aspen Creek Study Area.
- Figures 2 and 3 are cross-sectional views that summarize lithologic, water-level, and water-quality data. They also illustrate the relationships between the data collected at LOC-39 and LOC-40 east of Aspen Creek and data from previously installed RI monitoring wells located west of Aspen Creek in the Aspen Creek Study Area.

The remainder of this letter presents supporting documents and a summary of: 1) work planning and the work performed, 2) field observations, 3) potentiometric head measurements, and 4) laboratory results associated with the installation and sampling of monitoring wells MW-49 and MW-48 at the LOC-39 and LOC-40 locations during the 2016 field season. Our conclusions and recommendations, including the determination that no additional wells should be installed at these locations, are presented at the closing of this letter.

WORK PLANNING AND WORK PERFORMED

The U.S. EPA approved the Drilling Work Plan on August 16, 2016. Wells were installed in July and August 2016 and Atlantic Richfield provided preliminary observations and results for LOC-39 and LOC-40 and summarized field decisions regarding these locations to the U.S. EPA in a technical meeting on September 29, 2016.

Among the drilling locations described in the Drilling Work Plan, boreholes and wells were scheduled for installation along the perimeter of Aspen Creek at LOC-37, LOC-38, LOC-39, and LOC-40 (Figure 1). Primary objectives for these perimeter wells, reiterated in the U.S. EPA approval letter, were to confirm the assumption in developing the conceptual site model regarding the lack of off-site migration of mine-impacted groundwater at Aspen Creek. One shallow monitoring well per location was initially planned for LOC-39 and LOC-40. The need for optional deep wells was to be determined using pre-identified criteria that were presented in the Drilling Work Plan. Information collected from the shallow-depth wells was to be used in evaluating the existence and possibly the flow direction of groundwater in relation to Aspen Creek. If water levels and water quality in the shallow wells indicated that groundwater was flowing away from Aspen Creek and potentially off-site, a determination would then be made as to whether the optional deeper wells were needed to support lateral and vertical characterization of site-related groundwater impacts.

The Drilling Work Plan contained language to help guide field interpretation and decisions about installation of the optional wells as follows:

> "At this site, water levels in developed monitoring wells are not always similar to water levels observed in open boreholes during drilling. Consequently, water levels in the

> relatively shallower monitoring wells at LOC-39S and LOC-40S will be obtained after these wells have been constructed and developed. The top of well screens for monitoring wells at LOC-39S and LOC-40S will be targeted below the elevation of the nearby creeks to ensure that the screened intervals will not extend across the bottom elevation of the creek.
>
> Water levels from the newly installed and developed monitoring wells at LOC-39S and LOC-40S will be compared to surface water elevations in nearby Aspen Creek. If water level elevations in the shallower monitoring wells are higher than the elevation of surface water in nearby Aspen Creek, Atlantic Richfield recommends that the deeper, co-located monitoring wells not be installed because groundwater would be interpreted to be flowing toward Aspen Creek. If water level elevations in the shallower monitoring wells are not higher than surface water in nearby Aspen Creek, then the deeper, co-located wells should be installed to obtain vertical groundwater gradient information."

As discussed in the technical meeting on September 29, 2016, field conditions encountered at perimeter locations LOC-37, LOC-39, and LOC-40 resulted in a modification of these prescribed guidelines. Drilling procedures included stopping and checking for groundwater at least every 20 feet of penetration and at lithology changes. At all three locations, saturated conditions were encountered at relatively shallow depths ranging from 20 to 67 feet below ground surface (bgs). Shallow grab groundwater samples were collected from these shallow zones at depths of 30 and 67 feet bgs at LOC-40 and LOC-39, respectively. These grab samples had relatively low dissolved solids based on specific electrical conductivity (SEC) measurements of less than 250 micro Siemens per centimeter (µS/cm). Subsurface materials below these shallow zones were not saturated for an additional approximately 40 to 60 feet of drilling depth where a deeper saturated zone was encountered (Figures 2 and 3). It thus appeared that these shallow saturated zones consisted of isolated groundwater regimes potentially fed by or representing infiltration of surface runoff. Measurements indicated that shallow groundwater was not connected to nor representative of a deeper, site-wide groundwater regime monitored by several onsite RI wells installed west of Aspen Creek in the Aspen Creek Study Area.

Consequently, a decision was made to forego installation of shallow wells at the depth of first-encountered groundwater and, instead, to continue drilling to deeper depths at all three locations. At all locations as previously stated, a deeper saturated zone was encountered with potentiometric and field-measured and laboratory-analyzed water-quality characteristics consistent with site-wide groundwater conditions. These relationships and comparisons are illustrated on Figures 2 and 3, and the preliminary laboratory results of groundwater samples collected in wells MW-48 and MW-49 are provided in Tables 2 and 3. Therefore, monitoring wells were installed only in the relatively deeper saturated zone at both LOC-39 (MW-49) and LOC-40 (MW-48).

FIELD OBSERVATIONS

At LOC-39 and LOC-40, groundwater present in the shallowest saturated zones is isolated from the relatively deeper zone(s) (Figures 2 and 3) and likely represents infiltration of runoff of the yearly snowpack or rainfall originating from upslope areas to the east and southeast of both

these locations. Groundwater in the shallow saturated zones appears to be of meteoric origin based upon field-measured water-quality characteristics of grab samples collected in the shallow zones during borehole drilling. Groundwater in these shallow zones presumably originates as infiltration of precipitation in topographic sub-basins upslope of LOC-39 or in the thick, unconsolidated colluvial materials encountered adjacent to Aspen Creek near LOC-40. In both cases, these conditions are different from the shallow-level groundwater regime created by the deposition of the mine waste materials west of Aspen Creek. Field parameter measurements in shallow zone grab groundwater samples collected during drilling at LOC-39 and LOC-40 are shown on Table 3 and Figures 2 and 3. These samples indicated circumneutral pH values and SEC measurements of less than 250 µS/cm indicating relatively low dissolved solids content in groundwater at both locations.

POTENTIOMETRIC HEAD MEASUREMENTS

At LOC-40, potentiometric heads in the shallow saturated zone observed in the borehole during drilling and from the developed monitoring well MW-48 installed in the deeper saturated zone are both higher than the elevation of Aspen Creek (Figure 2). Heads in both these zones suggest flow toward Aspen Creek, and a north-northwest groundwater flow direction is inferred by interpolating water levels in MW-48 together with other site-wide monitoring wells (Figure 1).

At LOC-39, potentiometric heads observed in the borehole during drilling in both the shallower and deeper saturated zones, and in the developed monitoring well MW-49, are lower than the elevation of the adjacent Aspen Creek (Figure 3). However, potentiometric heads measured in MW-49, interpolated together with heads in deeper wells in the Aspen Creek Study Area, show consistent north-northwest groundwater flow directions toward the confluence of Aspen and Leviathan Creeks (Figure 1). The combined potentiometric head data indicate groundwater flow direction is primarily controlled by the current topographic slope, and there does not appear to be a direct hydraulic connection to Aspen Creek near MW-37 or LOC-39. The data indicate that groundwater emanating from the disturbed portion of the site does not flow offsite to the east away from Aspen Creek.

LABORATORY RESULTS

Preliminary laboratory results from groundwater samples collected in MW-48 and MW-49 are provided in Tables 2 and 3. Note that summary groundwater grab sample results from the shallow saturated zones at LOC-39 and LOC-40 are described in Table 1 and selected grab sample results are also included on Figures 2 and 3. These grab sample results are screening-level data and the intent of their collection was to primarily aid in field decisions about borehole depths and monitoring well design. However, they are included herein as the screening-level results are also useful to qualitatively illustrate the similarity (or differences) in water quality between the shallow and deeper saturated zones.

Groundwater from MW-48, representing the deeper saturated zone at LOC-40, is a calcium-bicarbonate type water with a low total dissolved solids (TDS) content (181 milligrams per liter [mg/L]), and low sulfate concentration (4.79 mg/L). The pH value of 7.78 suggests presence of calcium carbonate that buffers groundwater. Dissolved-metals concentrations in groundwater

from MW-48 are relatively low or not detected, and there are no dissolved-metal concentrations above established federal or state groundwater maximum concentration levels. Groundwater chemistry in the deeper saturated zone is not affected by mine-related activities at LOC-40. It is characterized by lower TDS, sulfate, and certain dissolved-metal concentrations (e.g., arsenic, manganese, nickel, zinc) in contrast to these same constituents in wells installed west of Aspen Creek (Figure 2).

Groundwater from MW-49, representing the deeper saturated zone at LOC-39, is a calcium-sodium bicarbonate type water, and there is a larger contrast in groundwater geochemistry between shallow and deep zones at LOC-39 as compared to LOC-40 based upon combined field screening-level and laboratory water-quality results (Table 3, Figures 2 and 3). Field pH values from the shallow zone grab sample collected at LOC-39 (6.91) and the deeper zone sample collected from monitoring well MW-49 (7.24) are similar, but the field SEC values for the shallow and deep zones (246 and 629 µS/cm, respectively) indicate slightly higher TDS concentrations in groundwater in the deeper zone at LOC-39. Sulfate concentrations in the shallow and deep zones at LOC-39 are also similar to a value of 39 mg/L (field measured) measured in the shallow zone grab sample as compared to 74.2 mg/L (lab measured) in the deeper zone sample. Similar to LOC-40, groundwater chemistry in the deeper saturated zone at LOC-39 is not affected by mine-related activities based on lower TDS, sulfate, and certain dissolved-metal concentrations (e.g., arsenic, manganese, nickel, zinc) in contrast to these same constituents in wells installed west of Aspen Creek (see MW-28 and MW-37 shown on Figure 2).

CONCLUSIONS AND RECOMMENDATIONS

Although monitoring wells at LOC-39 and LOC-40 were installed deeper than initially planned, and shallow wells were not installed in first encountered groundwater, water level and geochemistry data from monitoring wells MW-48 and MW-49 clearly demonstrate that additional wells are not necessary at either location. Detailed technical results, interpretations, and the rationale supporting this conclusion are provided in Table 1. A summary of key findings is provided below:

- Groundwater emanating from the disturbed portion of the site does not appear to flow offsite to the east beneath or away from Aspen Creek. Potentiometric data collected along the northeast perimeter of the disturbed portion of the site indicate groundwater flow is to the north-northwest toward the disturbed area of the site and toward the confluence between Aspen and Leviathan Creeks.
- Groundwater in the shallow saturated zones is likely of meteoric origin based upon field-measured water-quality characteristics of grab samples collected in the shallow zones during borehole drilling. Groundwater in these shallow zones presumably originates as infiltration of precipitation in topographic sub-basins upslope of LOC-39 or in the thick, unconsolidated colluvial materials encountered adjacent to Aspen Creek near LOC-40.

- Field parameter measurements and laboratory results indicate that the groundwater chemistry at LOC-39 and LOC-40 are of a different chemical character than groundwater conditions observed in wells installed west of Aspen Creek as evidenced by circumneutral pH values, sulfate concentrations of less than 100 mg/L, and TDS concentrations of less than 500 mg/L. Groundwater chemistry in the deeper saturated zones at LOC-39 and LOC-40 is not affected by mine-related activities based on lower TDS, sulfate, and certain dissolved-metal concentrations (e.g., arsenic, manganese, nickel, zinc) in contrast to these same constituents in wells installed west of Aspen Creek.

Based upon these findings, monitoring wells MW-48 and MW-49 fully satisfy the objectives set forth in the 2016 Drilling Work Plan. Additional monitoring wells are not needed to support the characterization of potential groundwater impacts in the Aspen Creek Study Area and should not be installed.

Atlantic Richfield recommends that monitoring wells MW-48 and MW-49 be added to the groundwater monitoring network for additional sampling during the 2017 field season to evaluate temporal changes in groundwater chemistry in these newly installed wells.

Sincerely,

Anthony R. Brown
Project Manager, Mining

Attachments:

Table 1 Results and Recommendations – 2016 Drilling and Monitoring Well Installation at LOC- 39 and LOC-40
Table 2 Preliminary Groundwater Results – Dissolved RI/FS Metals in Wells MW-48 and MW-49
Table 3 Preliminary Groundwater Results – Field Parameters and General Chemistry in Monitoring Wells MW-48 and MW-49
Figure 1 November 2016 Potentiometric Surface
Figure 2 Cross Section A-A'
Figure 3 Cross Section B-B'

cc: Gary Riley, U.S. Environmental Protection Agency, Region 9 – via electronic copy
John Hillenbrand, U.S. Environmental Protection Agency, Region 9 – via electronic copy
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Nathan Block, Esq., BP – via electronic copy
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Grant Ohland, Ohland HydroGeo, LLC – via electronic copy
Dave McCarthy, Copper Environmental Consulting – via electronic copy
Cory Koger, U.S. Army Corps of Engineers – via electronic copy
Greg Reller, Burleson Consulting – via electronic copy
Ken Maas, U.S. Forest Service, Humboldt-Toiyabe National Forest – via electronic and hard copy
Michelle Hochrein, Washoe Tribe of California and Nevada – via electronic copy and hard copy
Fred Kirschner, AESE, Inc. – via electronic copy and hard copy

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TABLES

TABLE 1
RESULTS AND RECOMMENDATIONS – 2016 DRILLING AND MONITORING WELL INSTALLATION AT LOC-39 AND LOC-40
Leviathan Mine Site
Alpine County, California

Borehole ID [Monitoring well ID][1, 2]	Work Plan	Results/Observations	Preliminary Interpretations	Conclusions / Recommendations
LOC-39S [NA]	• Characterize subsurface conditions at the perimeter of the On-Property Study Area near Aspen Creek east and cross gradient of the Aspen Creek Study Area. • Compare subsurface groundwater quality at the perimeter of the On-Property Study Area near Aspen Creek stream depositional areas to wells in the Aspen Creek Study Area beneath mine-waste, disturbed, or regraded areas. • Provide a data point to evaluate groundwater flow directions in areas east of Aspen Creek. • Potentially, determine if groundwater flow is toward or away from Aspen Creek. • Target screen zone based on elevations of saturated conditions and elevation of the nearby Aspen Creek. • Provide additional data point to evaluate site-wide groundwater potentiometric surface and groundwater flow directions.	• See location of MW-49 on Figure 1 for LOC-39 borehole location. Location is east of Aspen Creek, approximately 1,500 ft E of MW-42. The surface elevation at MW-49 was surveyed at 7,010 ft msl. • Borehole location is about 130 feet from Aspen Creek. The elevation of Aspen Creek adjacent to LOC-39 is approximately 6,960 ft msl • Total depth drilled = 145 ft bgs (approximately 6,865 ft msl) • Unconsolidated colluvial / talus material was logged to 88 ft bgs, then massive, chloritized sandstone to total depth. Unconsolidated materials appear oxidized zone (reddish brown soils/mottling) relative to grayish-green sandstone to total depth. The color difference may simply be a function of relict lithology. • A shallow saturated zone was encountered from approximately 67 to 83 ft bgs (6,943 to 6,927 ft msl), or about 20 feet below the elevation of the adjacent Aspen Creek. Potentiometric heads during drilling in this upper zone stabilized at about 6,942 ft msl. • A deeper saturated zone was encountered from approximately 127 ft bgs (approximately 6,883 ft msl) to total depth. • Aquifer materials between these two zones (83 to 127 ft bgs) did not yield groundwater while drilling • A potentiometric head during drilling at about 6,880 ft msl was observed in the lowermost open-hole interval at total depth (while borehole was cased to 125 ft bgs and open to 145 ft bgs). • Three water-quality grab samples were collected: one from the shallow saturated zone and two from the deeper zone. All samples are neutral pH. The shallow zone sample was relatively more dilute (SEC at 250 uS/cm and sulfate at 39 mg/l) relative to the deeper zone samples (SEC 800-900 uS/cm and sulfate at 77-84 mg/l) • Well MW-49 was constructed with a screen interval from 124.6 to 144 ft bgs (approximately 6,886 to 6,866 ft msl or about 85 feet deeper than the elevation of the adjacent Aspen Creek. • The water level elevation measured in well MW-49 in November 2016 was 6,913.05 ft msl, or about 47 feet lower than the elevation of the adjacent Aspen Creek. • A groundwater sample was collected in well MW-49 in late October 2016. Selected preliminary laboratory results (in mg/L) are as follows: TDS (403), bicarbonate (263), sulfate (74), calcium (47), arsenic (0.0191). Results indicate a calcium-bicarbonate type water with TDS with the range of that observed in deeper bedrock wells upgradient in the Aspen Creek Study Area (PZ-07, MW-27, MW-30, MW-32, MW-38). All dissolved metals except arsenic are below their respective MCL values or screening levels (if available), and arsenic is also within the same range as the upgradient wells cited above.	• The upper saturated zone appears isolated from the deeper saturated zone, separated by open-hole drilling that produced no groundwater in the borehole. The upper saturated zone is presumably associated with relatively shallow level infiltration / recharge from snowmelt or runoff in the unconsolidated materials adjacent to Aspen Creek in this area. • Potentiometric heads in the lower zone are consistent with an eastward projection of potentiometric heads of deeper wells located west of the creek (MW-41, MW-30, MW-32; see Figure 1). These deeper saturated zones appear to be connected. • Potentiometric heads measured in MW-49, together with heads in deeper wells in the Aspen Creek Study Area, suggest consistent N-NW groundwater flow directions toward the confluence of Aspen and Leviathan creeks (Figure 1). The groundwater flow directions are primarily controlled by the overall topographic slope and do not appear to be influenced by or connected to the Aspen Creek drainage channel at this location Groundwater does not appear to flow off site away from Aspen Creek. • The presence of the upper saturated zone at LOC-39, together with similar observed shallow saturated zones at LOC-40 (MW-48) and LOC-37 (MW-53), supports a conceptual model of near-surface groundwater occurring at shallow levels beneath the hummocky and slumped (landslide ?) terrain rising toward the E-SE to the east of Aspen Creek. The shallow groundwater is likely the result of infiltration of runoff of the yearly snowpack of meteoric origin that is potentially collecting in backfill sub-basins in slumped, landslide topography.	• Although potentiometric heads in the borehole during drilling and in the developed monitoring well MW-49 are lower than the elevation of the adjacent reach of Aspen Creek, the overall potentiometric interpolation using all the site- wide data (Figure 1) do not support an interpretation of perimeter groundwater flow away from Aspen Creek. Rather, data from all the perimeter wells installed east of Aspen Creek support an overall groundwater flow direction to the N-NW toward the confluence of Leviathan and Aspen creeks. Overall groundwater flow direction is consistent with the site-wide topographic slope from SE to NW. • Potentiometric or water quality data in the upper saturated zone is of limited value. Potentiometric head data from the shallow zone observed at LOC-39 cannot be connected or paired with head data from deeper-zone wells to the west across Aspen Creek. These represent two separate groundwater regimes based on the topographic and lithologic settings of shallow-zone groundwater east of the creek and deeper-zone groundwater west of the creek. Although there is shallow and potentially perched water observed in the toe area of mine waste south of LOC-39 and/or perched water in landslide materials directly west of LOC-39, it is unlikely that head data from those shallow groundwater zones in the Aspen Creek Study Area should be connected with shallow groundwater observed at LOC-39 as the topographic setting and mechanisms controlling shallow groundwater flow in these areas are much different. • Water quality/type in the upper groundwater zone at LOC-39 is likely of meteoric origin associated with runoff infiltration. Water-quality data from the shallow zone at LOC-39 is of limited value in comparison with shallow-zone impacted waters from shallow wells installed in mine waste in the Aspen Creek Study Area because the source of the high TDS and dissolved-metal rich shallow groundwater west of the creek (mine waste) is very evident and is not present east of Aspen Creek at LOC-39. • Water-quality data from a shallow well at LOC-39 would likely characterize waters of meteoric origin and would not be suitable for comparison with the deeper level groundwater comprising underflow beneath the creek and Aspen Creek Study Area because these are separate groundwater regimes. • Head data from the shallow saturated zone at LOC-39 cannot be used to discern or improve the interpretation of groundwater flow direction as the shallow groundwater at this location would be an isolated data point. • **Recommendation: Do not install an additional well in the shallow zone at LOC-39.**
LOC-39D (Optional) [MW-49]	• If groundwater levels in LOC-39S indicate flow toward Aspen Creek, then the installation of LOC-39D should not be required. If groundwater levels in LOC-39S indicate flow is not toward Aspen Creek, then: ◦ Characterize deeper subsurface conditions outside the limits of the mine waste, cross groundwater gradient of the Aspen Creek Study Area. ◦ Characterize deeper groundwater flow direction. ◦ Provide data to calculate vertical hydraulic groundwater gradient in this area.			

TABLE 1
RESULTS AND RECOMMENDATIONS – 2016 DRILLING AND MONITORING WELL INSTALLATION AT LOC-39 AND LOC-40
Leviathan Mine Site
Alpine County, California

Borehole ID [Monitoring well ID][1, 2]	Work Plan	Results/Observations	Preliminary Interpretations	Conclusions / Recommendations
LOC-40S [NA]	• Characterize subsurface conditions at the perimeter of the On-Property Study Area near Aspen Creek east and cross gradient of the Aspen Creek Study Area. • Compare subsurface groundwater quality at the perimeter of the On-Property Study Area near Aspen Creek to wells in the Aspen Creek Study Area beneath mine-waste, disturbed, or regraded areas. • Provide a data point to evaluate groundwater flow directions in areas east of Aspen Creek. • Potentially, determine if groundwater flow is toward or away from Aspen Creek • Target screen zone based on elevations of saturated conditions and elevation of the nearby Aspen Creek. • Provide additional data point to evaluate site groundwater potentiometric surface and groundwater flow directions.	• See location of MW-48 on Figure 1 for LOC-40 borehole location. Location is E-SE of Aspen Creek, approximately 980 ft east of MW-37. Surface elevation at MW-48 is approximately 7,200 ft msl. • The stream elevation of Aspen Creek at the confluence of Aspen Creek and tributary (upstream of MW-37) is approximately 7,135 ft msl, and Aspen Creek adjacent to LOC-40 in the nearby meadow is at approximately 7,180 ft msl. • Total depth drilled = 110 ft bgs (approximately 7,090 ft msl) • Unconsolidated alluvial/colluvial material was logged to total depth, bedrock was not encountered. Oxidized zone (reddish brown soils/mottling) to approximately 55 ft bgs 7,145 ft msl) • A shallow saturated zone was encountered from approximately 30 to 40 ft bgs (7,170 to 7,160 ft msl), or about 10 to 20 feet below the elevation of Aspen Creek in the adjacent stream in meadow. Potentiometric heads in the open borehole through this interval stabilized at approximately 13 ft bgs (7,187 ft msl) or about 7 feet above the elevation of the adjacent stream. • A deeper saturated zone was encountered from approximately 95 ft bgs (approximately 7,105 ft msl) to total depth; approximately 30 ft below the elevation of Aspen Creek at the confluence of tributary stream upstream of MW-37. • Aquifer materials between these two saturated zones did not yield groundwater while drilling. • There are high potentiometric heads encountered in the lower saturated zone, stabilizing at about 13 ft bgs (approximately 7,187 ft msl) in the borehole when cased to 100 ft bgs and open to 110 ft bgs. This is about 7 feet higher than the elevation of Aspen Creek in the adjacent meadow. • Three water-quality grab samples were collected: one from the shallow saturated zone and two from the deeper zone. All samples are neutral pH, relatively dilute (SEC 190 to 230 uS/cm), with very low sulfate (<10 mg/L). • Well MW-48 was constructed with a screen interval from 94 to 109 ft bgs (approximately 7,106 to 7,091 ft msl or about 37 feet deeper than the elevation of Aspen Creek at the confluence of the tributary upstream of MW-37). • The water level elevation measured in well MW-48 in November 2016 was 7,186.43 ft msl, or about 8 feet higher than the elevation of the adjacent Aspen Creek. • A groundwater sample was collected in well MW-48 in late October 2016. Selected preliminary laboratory results (in mg/L) are as follows: TDS (181), bicarbonate (117), sulfate (4.8), calcium (25). Results indicate a very dilute, calcium-bicarbonate type water. All dissolved metals are below their respective MCL values or screening levels (if available).	• The upper saturated zone appears isolated from the deeper saturated zone, separated by open-hole drilling that produced no groundwater in the borehole. The upper saturated zone appears to be associated with relatively shallow level infiltration / recharge from snowmelt or runoff in the unconsolidated materials infilling the meadow adjacent to Aspen Creek in this area. • Potentiometric heads in the lower zone are consistent with an eastward projection of potentiometric heads from deeper wells west of the creek (MW-34, PZ-25, MW-37; see Figure 1). These deeper saturated zones appear to be connected. • Potentiometric heads in both the shallow and deeper saturated zones are about 7 feet higher than the elevation of Aspen Creek in the adjacent meadow, suggesting groundwater flow toward the Creek. A W-NW flow toward the creek at this location is indicated in the site-wide potentiometric map on Figure 1. • Potentiometric heads in MW-48 (LOC-40), together with heads in deep wells in Aspen Creek Study Area, suggest consistent overall N-NW groundwater flow directions dictated by the overall topographic slope with highlands /recharge areas upslope to the S-SE of the monitoring well network. Site-wide potentiometric data incorporating all new data from the perimeter wells installed east of Aspen Creek do not support off-site migration of groundwater. Rather, overall groundwater flow appears to be towards the confluence of Aspen and Leviathan creeks (Figure 1). • The presence of the upper saturated zone at LOC-40, together with similar observed shallow saturated zones at LOC-39 (MW-49) and LOC-37 (MW-51), supports a conceptual model of near surface groundwater occurring at shallow levels beneath the hummocky and slumped (landslide ?) terrain rising toward the E-SE to the east of Aspen Creek. The shallow groundwater may be the result of infiltration of runoff of the yearly snowpack of meteoric origin that is potentially collecting in backfill sub-basins in slumped, landslide topography.	• Potentiometric heads are higher than the elevation of Aspen Creek in the adjacent meadow in both the shallow and deeper saturated zones observed while drilling, and in the developed monitoring well MW-48 installed in the lower saturated interval. The overall potentiometric interpolation using all the site-wide data (Figure 1) support an interpretation of perimeter groundwater flow in a general N-NW direction toward Aspen Creek in the area of LOC-40. • Potentiometric or water-quality data in the upper saturated zone is of limited value as it is not necessary to substantiate groundwater flow directions. Potentiometric head and water-quality data are equivalent in both the shallow and deeper saturated zones. • Water quality/type in the upper zone is likely of meteoric origin associated with runoff infiltration. It is of limited value in comparison with shallow zone impacted waters to the west from shallow wells installed in mine waste in the Aspen Creek Study Area. • Water-quality data from a shallow well at LOC-40 would characterize waters of meteoric origin and may not be suitable for comparison with the deeper level groundwater comprising underflow beneath the creek and Aspen Creek Study Area. • **Recommendation: Do not install an additional well in the shallow zone at LOC-40.**
LOC-40D (Optional) [MW-48]	• If groundwater levels at LOC-40S indicate flow toward Aspen Creek, then the installation of LOC-40D should not be required. If groundwater levels in LOC-39S indicate flow is not toward Aspen Creek, then: ◦ Characterize deeper subsurface conditions outside the limits of the mine waste, cross gradient of the Aspen Creek Study Area. ◦ Characterize the deeper groundwater flow direction. ◦ Provide data to calculate vertical hydraulic groundwater gradient in this area.			

TABLE 1
RESULTS AND RECOMMENDATIONS – 2016 DRILLING AND MONITORING WELL INSTALLATION AT LOC-39 AND LOC-40
Leviathan Mine Site
Alpine County, California

Notes:
1. Borehole and monitoring well locations shown are on Figure 1. Monitoring well ID shown in bracket if a well was installed at the borehole location.
2. Monitoring wells installed in 2016 at perimeter drilling locations: LOC-37 = MW-51; LOC-38 = MW-50/MW-52; LOC-39 = MW-49; and LOC-40 = MW-48.

Abbreviations:
E = east
ft = feet
ft bgs = feet below ground surface
ft msl = feet above mean sea level
ID = identification
MCL = Maximum contaminant level
mg/L = milligrams per liter
MW = monitoring well
N = north
NA = not applicable
PZ = piezometer
S= south
SEC = Specific electrical conductance
TDS = Total dissolved solids
uS/cm = micro Siemens per centimeter
W = west

TABLE 2
PRELIMINARY GROUNDWATER RESULTS[1] - DISSOLVED RI/FS METALS IN MONITORING WELLS MW-48 AND MW-49[2]
Leviathan Mine Site
Alpine County, California

Study Area[3]	Location ID[3]	Sample ID	Sample Date	Sample Type	Dissolved Aluminum (mg/L)	Dissolved Antimony (mg/L)	Dissolved Arsenic (mg/L)	Dissolved Barium (mg/L)	Dissolved Beryllium (mg/L)	Dissolved Cadmium (mg/L)	Dissolved Chromium (mg/L)	Dissolved Cobalt (mg/L)	Dissolved Copper (mg/L)	Dissolved Hexavalent Chromium (mg/L)	Dissolved Iron (mg/L)	Dissolved Lead (mg/L)	Dissolved Manganese (mg/L)	Dissolved Mercury (mg/L)	Dissolved Nickel (mg/L)	Dissolved Selenium (mg/L)	Dissolved Silver (mg/L)	Dissolved Thallium (mg/L)	Dissolved Vanadium (mg/L)	Dissolved Zinc (mg/L)
ACSA	MW-48	GWA10041601	10/4/2016	NE	0.006 J	0.000067	0.00146	0.0638	<0.00004	<0.00002	0.00026	0.00003	0.00024	0.00039 J	<0.02	0.000045	0.06	<0.0002	0.00024	<0.001	<0.00002	0.000004 J	0.00367	0.00607
ACSA	MW-48	GWA10261601	10/26/2016	NE	<0.01	0.000067	0.00137	0.0571	<0.00002	<0.00002	<0.00024 U	0.000053	0.00016	<0.001	<0.02	0.00001 J	0.0533	<0.0002	0.00035	<0.001	<0.00002	0.000004 J	0.00323	0.00246
ACSA	MW-49	GWA09231602	9/23/2016	NE	<0.01	0.000627	0.0243	0.0243	<0.00002	<0.000006 U	0.00003 J	0.00021	<0.00009 U	<0.001	0.032	<0.000012 U	0.107	<0.0002	0.00115	<0.001	<0.00002	0.000045	0.00025	0.00838
ACSA	MW-49	GWA10251601	10/25/2016	NE	0.006 J	0.000713	0.0191	0.0195	<0.00002	0.000012 J	<0.00008 U	0.000217	0.00029	<0.001	<0.02	0.000014 J	0.104	<0.0002	0.00133	<0.001	<0.00002	0.000031	0.00028	0.00765

Note(s)
1. Validation of the laboratory results is in progress; however, the data are not fully validated as specified in the QAPP and are preliminary. The data are, however, of sufficient quality to perform the preliminary evaluation and interpretation.
2. Table presents laboratory results from groundwater samples collected from developed monitoring wells MW-48 and MW-49.
3. Locations are shown on Figure 1.

Abbreviation(s)
ID = identification
mg/L = milligrams per liter
NE = normal environmental (i.e., primary sample)
RI/FS = Remdial Investigation/Feasibility Study

Data Qualifiers

J The analyte was positively identified but the associated numerical value may not represent the actual concentration of the analyte in the sample due to analytical bias in precision or accuracy, or because the resulting trace concentration is below the respective quantitation limit.

U The analyte was analyzed for, but was not detected above the sample quantitation limit, or may be detected but due to contamination from an outside source such as laboratory or field equipment, the sample quantitation limit has been adjusted.

TABLE 3

PRELIMINARY GROUNDWATER RESULTS[1] - FIELD PARAMETERS AND GENERAL CHEMISTRY IN MONITORING WELLS MW-48 AND MW-49[2]

Leviathan Mine Site

Alpine County, California

Study Area[3]	Location ID[3]	Sample ID	Sample Date	Sample Type	Dissolved Oxygen (mg/L)	Field pH (su)	Field Turbidity (NTU)	Oxidation Reduction Potential (mV)	Specific Conductivity (uS/cm)	Temperature (degrees C)	Ferrous Iron (mg/L)	Acidity (mg/L)	Alkalinity (Bicarbonate) (mg/L)	Alkalinity (Carbonate) (mg/L)	Alkalinity (Hydroxide) (mg/L)	Alkalinity () (mg/L)	Ammonia (as N) (mg/L)	Total Calcium (mg/L)	Chloride (mg/L)	Hardness (mg/L)	Total Magnesium (mg/L)	Nitrate (as N) (mg/L)	Orthophosphate (as P) (mg/L)	Total Potassium (mg/L)	Total Sodium (mg/L)	Sulfate (mg/L)	Total Dissolved Solids (mg/L)
					Field Parameters							**Laboratory Results**																
ACSA	MW-48	GWA10041601	10/4/2016	NE	3.25	7.79	2.69	137.7	262	8.5	<0.03	<2	117	<2	<2	117	<0.05	26.5	1.86	105	9.53	0.32	0.039	2.85	13.1	4.74	157
ACSA	MW-48	GWA10261601	10/26/2016	NE	3.54	7.78	1.71	31.2	214	10.9	0.03	<2	117	<2	<2	117	0.023 J	25.3	1.64	101	9.07	0.34	0.05	2.56	11.7	4.79	181
ACSA	MW-49	GWA09231602	9/23/2016	NE	1.6	8.48	4.73	-3.1	636	12.45	<0.03	4	263	<2	<2	263	<0.05	47.4	4.8	188	17	<0.25	0.07	9.33	63.3	76	400
ACSA	MW-49	GWA10251601	10/25/2016	NE	1.77	7.24	5.06	-26	629	12.5	<0.03	4	263	<2	<2	263	0.023 J	47.3	7.36	195	18.6	<0.25	0.056	10.4	71.5	74.2	403

Note(s)

1. Validation of the laboratory results is in progress; however, the data are not fully validated as specified in the QAPP and are preliminary. The data are, however, of sufficient quality to perform the preliminary evaluation and interpretation.
2. Table presents laboratory results from groundwater samples collected from developed monitoring wells MW-48 and MW-49.
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FIGURES

P:\Project\13000s\13091 Leviathan\14000 Database_CAD\CAD\DrawingFiles\Groundwater\Nov2016PotentiometricSurface.mxd

LOC-38
MW-50 6579.58
Leviathan Creek
6700
LOC-39
Aspen Creek
B'
MW-49 6913.05
MW-42 6752.24
6800
6900
LOC-37
B
MW-41 6807.62
PZ-07 6807.49
MW-51 7042.11
MW-30 6973.31
7000
MW-32 7033.79
ASPEN CREEK STUDY AREA
MW-27 7057.85
LEVIATHAN CREEK STUDY AREA
MW-38 7062.15
MW-24 7105.83
LOC-40
7100
MW-37 7086.34
MW-48 7186.43
A'
MW-47 7104.04
MW-28 7114.61
MW-15 6832.31
MW-53 6842.88
MW-40 7115.94
A
MW-23 6851.61
MW-17 6856.36
MW-16 6837.25
MW-04 7133.69
7200
MW-14 6902.82
PZ-25 7282.53
PIT STUDY AREA
MW-03 7052.78
MW-13 6912.33
MW-34 7283.15
MW-10D 6895.34
PZ-38 6895.96
Lower Tributary
MW-11 6909.19
MW-08 6948.67
MW-02D 7011.94
MW-05D 7040.97
MW-20 6968.79
PZ-37 6956.94
PZ-39 6951.47
PZ-33 7237.65
PZ-46 7045.41
MW-07 7018.48
PZ-40 7024.88
PZ-41 7027.37
MW-45 7106.34
Upper Tributary

Explanation

- Monitoring Well
- Piezometer
- LOC-XX Original Borehole Name
- 7052.78 Potentiometric Surface Elevation (ft msl)
- 7100 Potentiometric Surface Contour (ft msl)
- A — A' Cross-Section Profile Line
- Study Area
- Creek

Notes:
1. ft msl - feet above mean sea level
2. Contour interval - 10 Feet
3. Base map from aerial photograph dated October 22, 2009.

N

0 1,000 Feet

NOVEMBER 2016
POTENTIOMETRIC SURFACE
Leviathan Mine Site
Alpine County, California

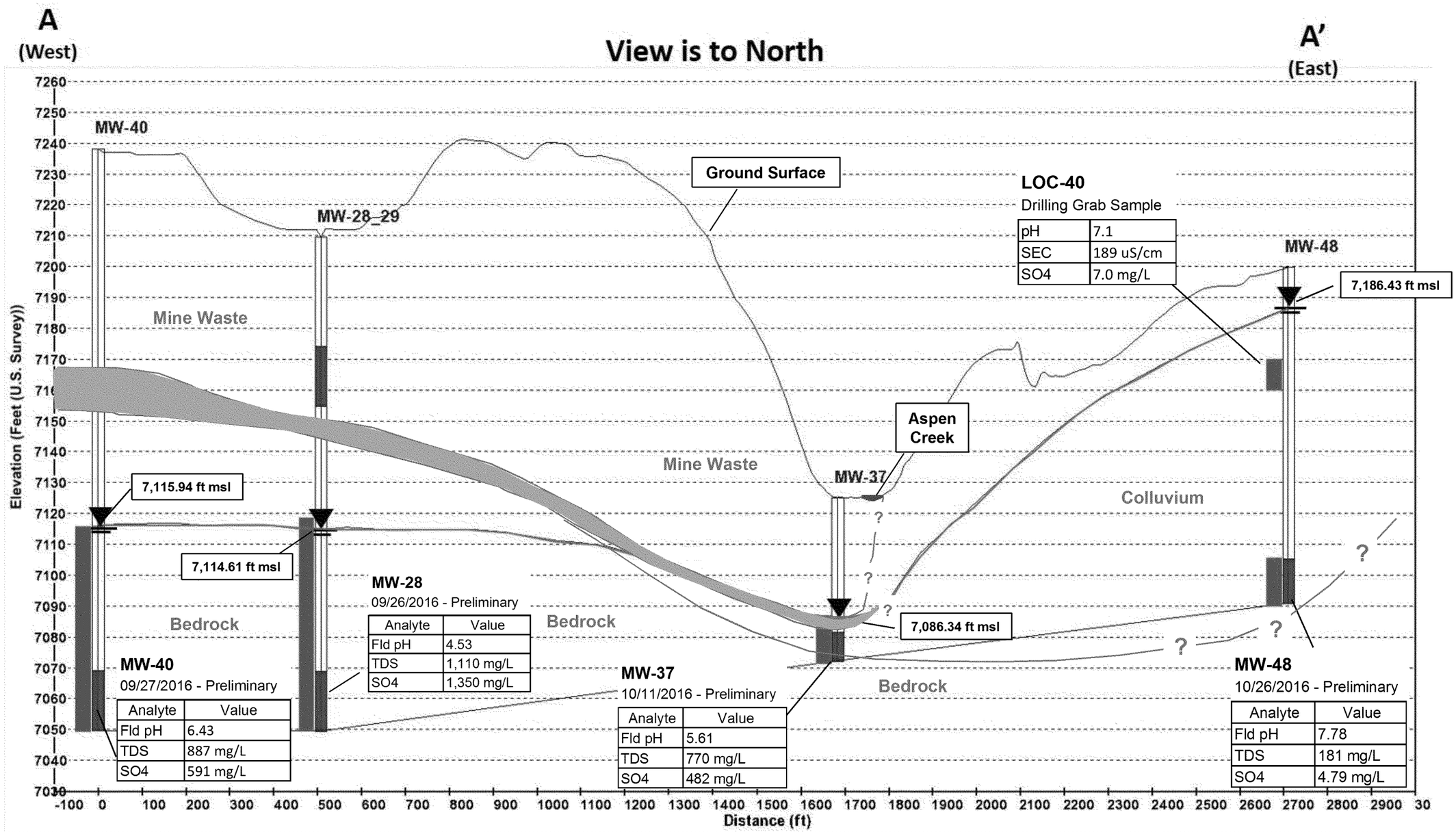
By: DPV
Date: 05/01/2017

Project No. 13091

amec foster wheeler

Figure 1

ED_001709_00001748-00015



Saturated Interval Encountered During Borehole Drilling

Monitoring Well Screen Interval

Potentiometric Surface November 2016

7,114.61 ft msl

Note: Water level elevation in feet above mean sea level measured in November 2016. See Figure 1 for plan view potentiometric surface map

Lithologic Contact – Queried Where Uncertain

Note: Profile locations are shown on Figure 1

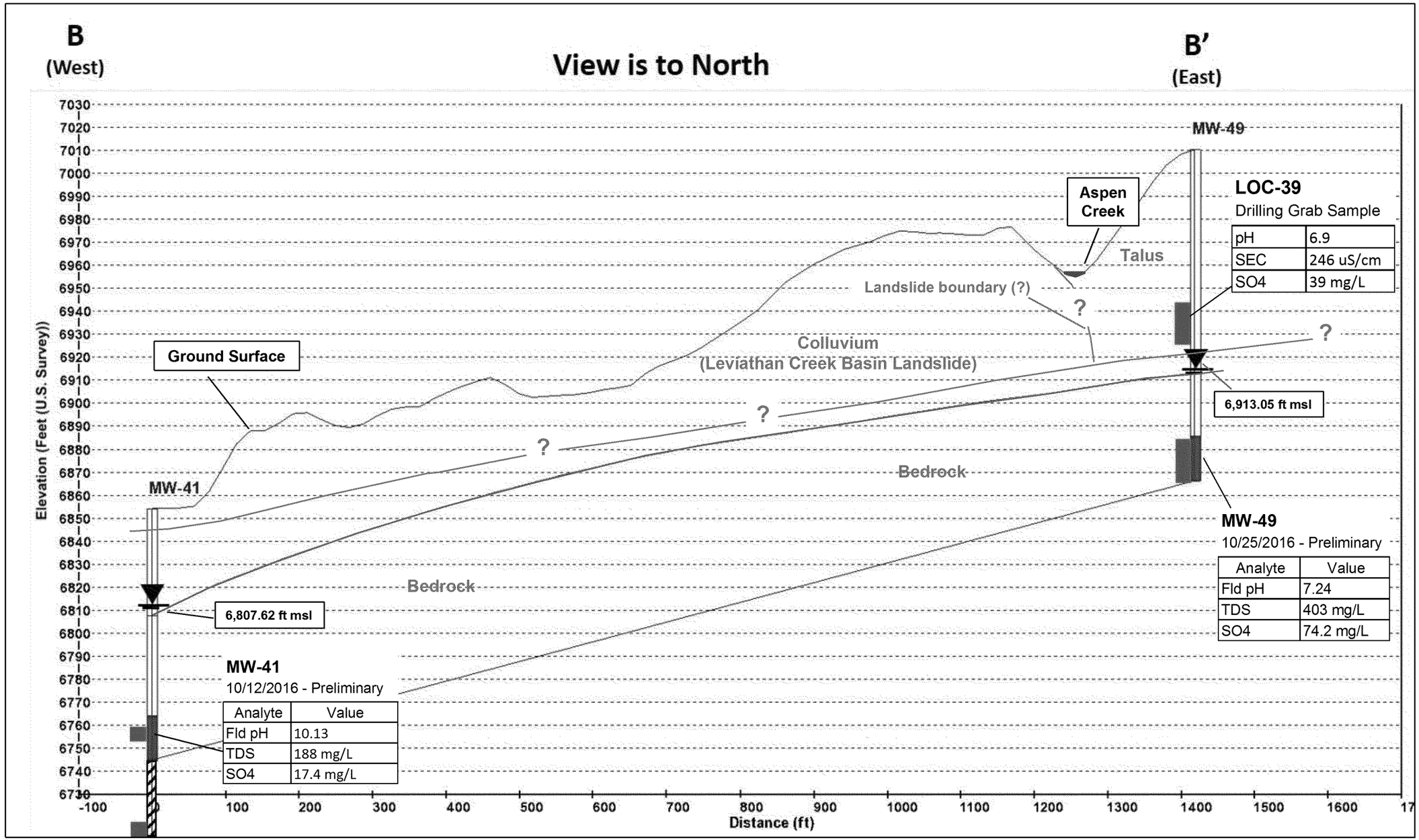
CROSS SECTION A-A'
Leviathan Mine Site
Alpine County, California

Date: 03/27/2017
By: CPE

Project No. 0013091

amec foster wheeler

Figure 2



Saturated Interval Encountered During Borehole Drilling

Monitoring Well Screen Interval

Potentiometric Surface November 2016

6,913.05 ft msl

Note: Water level elevation in feet above mean sea level measured in November 2016. See Figure 1 for plan view potentiometric surface map.

Lithologic Contact – Queried Where Uncertain

Note: Profile locations are shown on Figure 1

CROSS SECTION B-B'
Leviathan Mine Site
Alpine County, California

amec foster wheeler

Date: 03/27/2017

By: CPE

Project No. 0013091

Figure 3